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SOUNDING-BALLOON OBSERVATIONS AT OMAHA, NEBR., DURING THE INTERNATIONAL MONTHS JULY 1938 AND APRIL 1939

By L. F. HAFFER

[Weather Bureau, Washington, D. C., February 1940]

The Weather Bureau made daily sounding balloon observations at Omaha, Nebr., during the International Months of July 1938 and April 1939. These observations were similar to observations made during the International Months of previous years.

Forty-nine Fergusson meteorographs, each attached to a balloon carrying a Jaumotte meteorograph, were released during the July 1938 series, 12 of these observations being made to study the effect of insolation on the 2 types of instruments. Thirty-six Fergusson meteorographs were released during April 1939. In each of these months 1 observation was made each day about 1 hour before sunset in accordance with past practice during International Months. On the 6 International Days in each of these months, an additional observation was made just after sunrise.

The arrangement of equipment was as follows: Balloon, parachute, cord, combination of cord and rubber shock cord, and meteorographs.

The balloons used were of the 700-gram type. They were inflated to 1,100 grams free lift in order to secure an ascensional rate of about 360 or 380 meters per minute. For the first 29 days of the July series, the balloons were inflated with hydrogen, while on the last 2 days of July and for the entire April series they were inflated with helium. When the balloons were inflated with helium, they were somewhat larger, after inflation, than on days on which hydrogen was used.

Weather conditions permitting, the balloons were followed with two theodolites so that winds aloft could be determined, and also to serve as a check on the maximum heights as computed from the meteorograph records.

The parachutes used were made of red silk and were about 1 yard square in size.

Tables 1 and 2 show the tropopause and maximum elevation data for both series.

It will be noted that the maximum height to which a balloon was followed with two theodolites during the July series was 29,540 meters; and in April, 27,360 meters. The average computed maximum altitude for July was about 26 kilometers, which was about 4 kilometers higher than the April average. The greater heights reached by the instruments in July were due to the fact that hydrogen was used instead of helium. There may also have been a seasonal effect. In the April series the balloons generally burst about 12 minutes earlier than in July.

Figure 1 shows the mean temperature for each of the two series, plotted against height. July was warmer than April to about 13 kilometers and then colder to about 19 kilometers; above 19 kilometers the two curves are almost identical. The April temperature curve showed a tendency to become isothermal at about 25 kilometers, while in July the inversion in the stratosphere continued to the maximum elevation. This agrees with results obtained in previous years, which showed a seasonal variation in

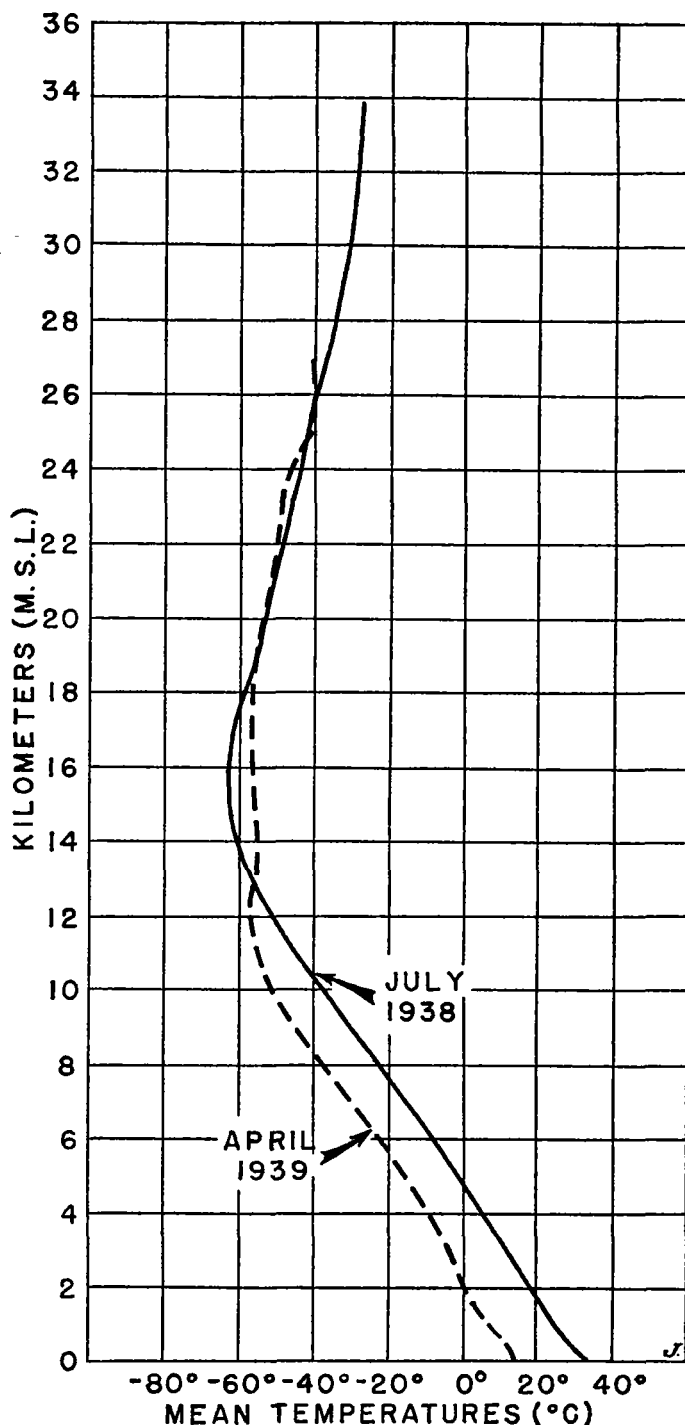


FIGURE 1.—Mean temperature for each of the two series, plotted against the height.

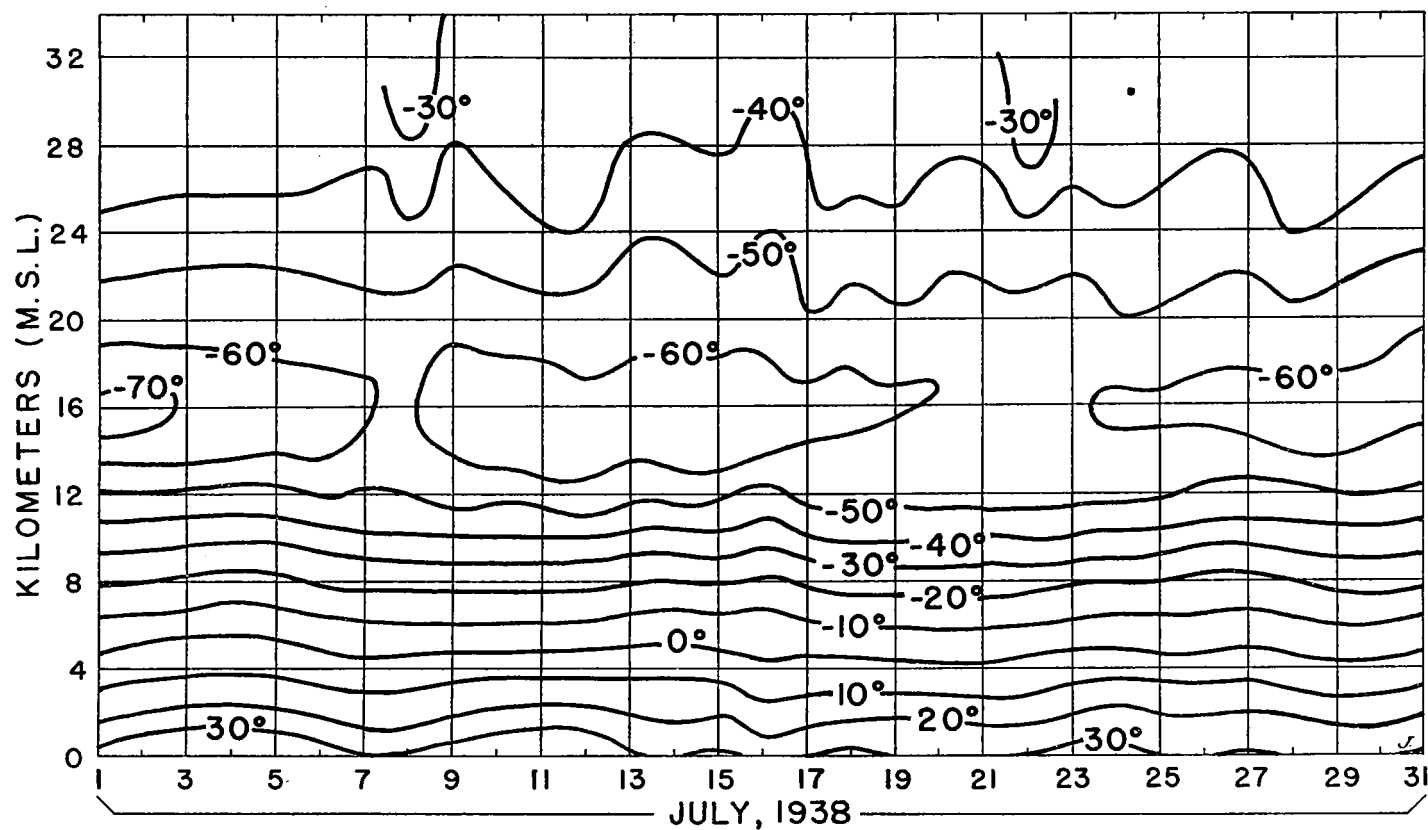


FIGURE 2.—Upper-air isotherms for July 1938.

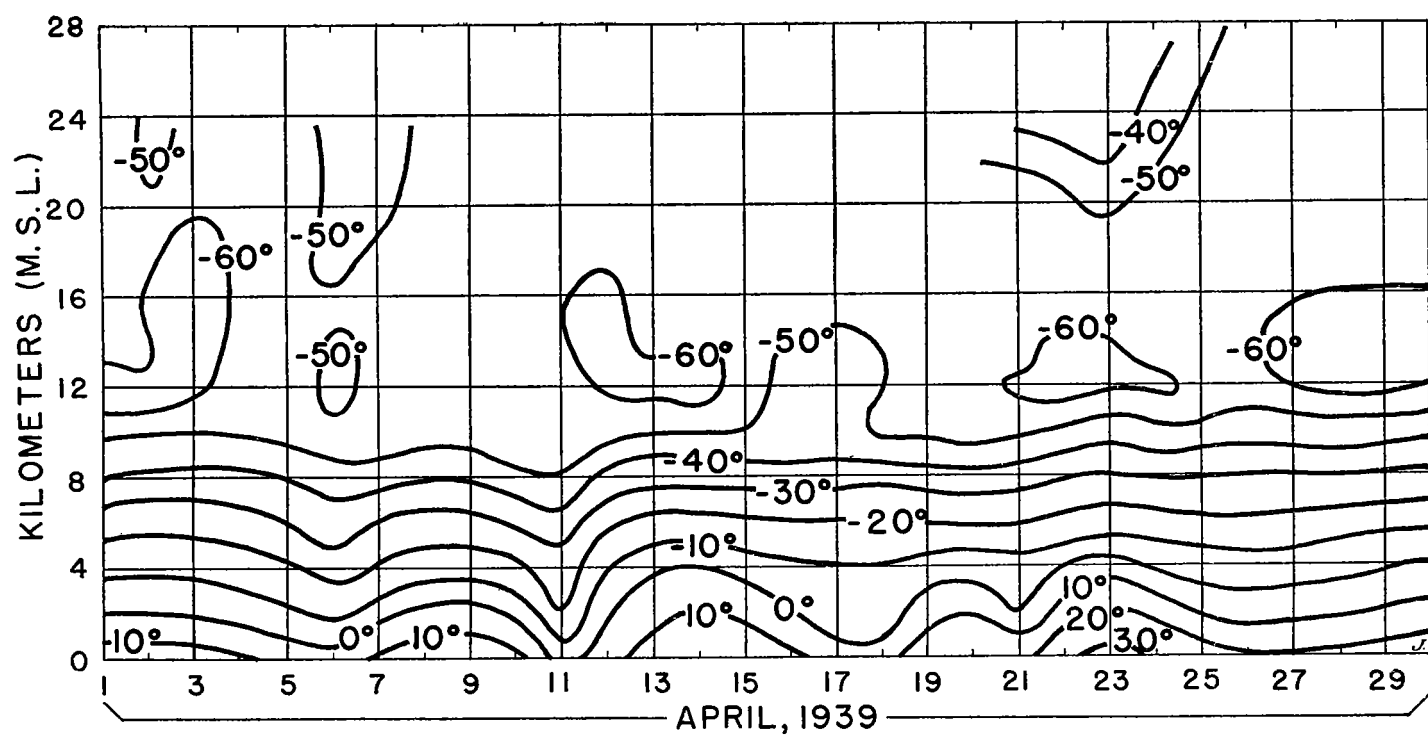


FIGURE 3.—Upper-air isotherms for April 1939.

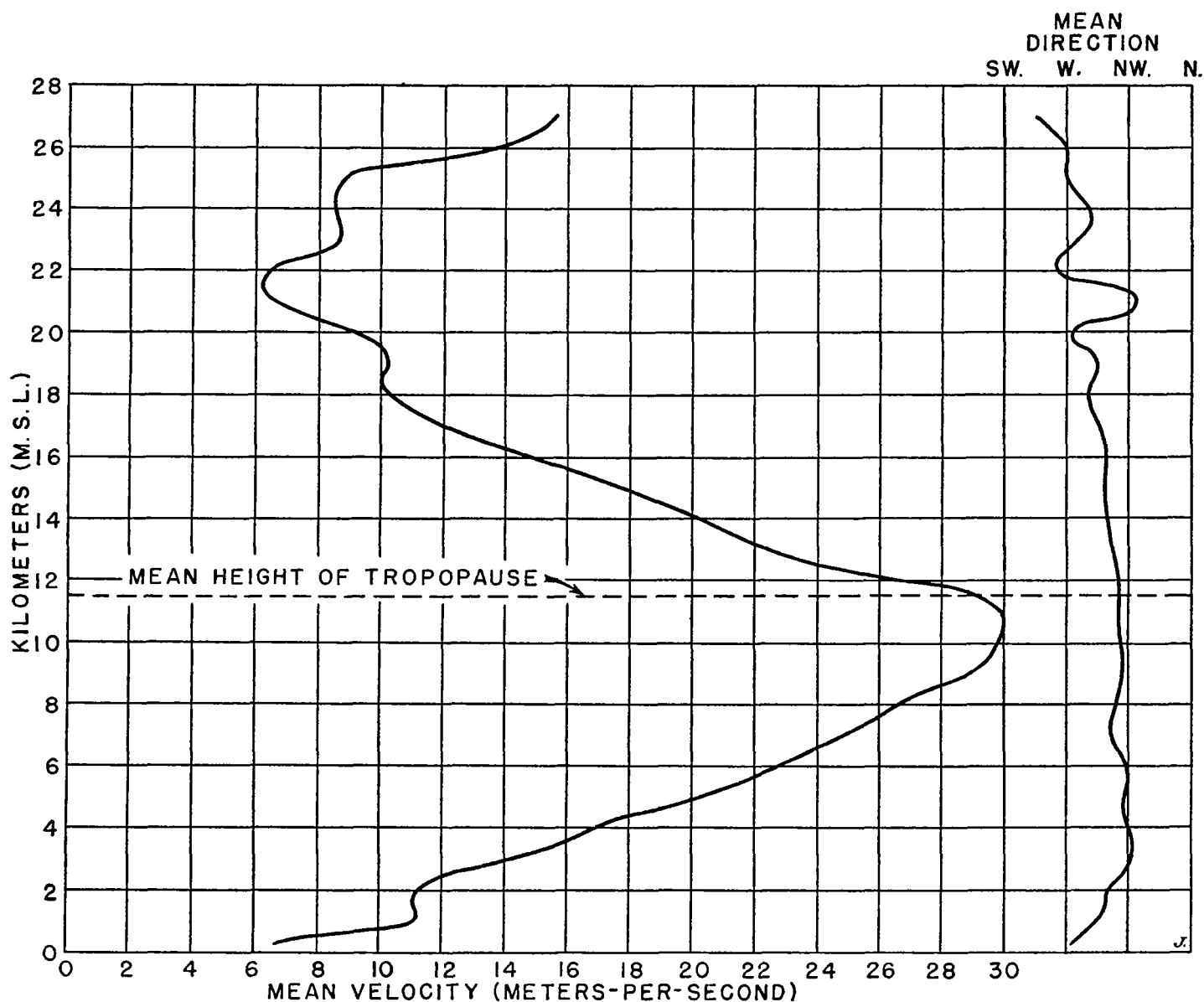


FIGURE 4.—Average wind velocity and direction plotted against height for the April 1939 series.

the amount of the temperature inversion in the stratosphere; the summer months show large inversions and the winter months little or no inversion.

Figures 2 and 3 show upper air isotherms for July 1938 and April 1939, respectively.

Table 3 shows the wind directions and velocities observed at the surface and at each standard kilometer level for the April series.¹

Figure 4 shows the average wind velocity and direction plotted against height for the April series. The maximum wind velocity occurred about 1 kilometer below the mean height of the tropopause. This occurrence of the maximum mean velocity at an altitude just below the mean height of the tropopause is in agreement with the results of previous years. The velocity showed a decrease from

11 to 22 kilometers, and then increased again from 22 kilometers to the maximum height.

A very noticeable feature of the wind direction curve is the lack of the easterly winds observed in the 2 previous years above 20 kilometers; and available data indicate these upper easterly winds to be a summertime condition.

A comparison of the Jaumotte instrument with the Fergusson and radiosonde in the July 1938 series showed the Jaumotte giving the least satisfactory results. The Jaumotte in many cases failed to indicate small inversions and isothermal layers shown by the other two instruments. In 7 cases out of 46, the Jaumotte showed negative pressure values at the highest levels, indicating that something occurred to disturb the original calibration. The calibrations of the Jaumotte appear to be disturbed rather easily by handling of the instrument. Table 1 shows better agreement between the Fergusson and the theodolite data than between the Jaumotte and the theodolite data.

¹ Wind data for the July 1938 series has been published in the Monthly Weather Review, November 1938.

TABLE 1.—Tropopause and maximum elevation data for July 1938

Date	Time of release, 90th Meridian	Minimum temperature, °C. Fergusson meteorograph	Temperature of tropopause, °C. Fergusson meteorograph	Height of tropopause m. (M. S. L.) Fergusson meteorograph	Maximum height m. (M. S. L.) Fergusson meteorograph	Maximum height m. (M. S. L.) Two-theodolite observations	Maximum height m. (M. S. L.) Jaumotte meteorograph
1	6:07 p.	-74.6	-74.6	15570	28690	(¹)	(²)
2	6:39 p.	-74.3	-74.3	16130	24450	25000	24250
3	6:38 p.	-70.7	-70.7	16410	21860	22180	(³)
4	6:34 p.	-68.0	-68.0	16770	24340	24330	36100
5	8:29 p.	-64.4	-64.2	14290	24150	(⁴)	17600
6	6:30 p.	(⁵)					
7	8:11 p.	-62.2			13600	(⁶)	34360
8	6:25 p.	-66.1	-66.1	15530	27480	(⁷)	21200
9	6:29 p.	-61.7	-60.1	15160	28820	28090	(⁸)
10	6:29 p.	-60.3	-59.9	15180	30460	29360	(⁹)
11	8:15 p.	-52.4			5800	(¹⁰)	(¹¹)
12	6:26 p.	-64.6	-63.2	14300	34360	29490	5800
13	8:12 p.	-67.5	-66.7	14850	27520	(¹²)	22800
14	6:24 p.	-62.7	-62.6	13940	28320	28520	28320
15	8:02 p.	-64.3	-63.5	14100	28420	(¹³)	(¹⁴)
16	6:21 p.	-65.5	-65.5	14910	27490	(¹⁵)	(¹⁶)
17	7:58 p.	-64.7	-64.7	16530	24870	(¹⁷)	18000
18	6:26 p.	-63.3	-62.7	13810	25960	27030	20400
19	8:07 p.	-59.9			13760	(¹⁸)	(¹⁹)
20	6:24 p.	-65.0	-65.0	16100	29540	29540	26400
21	8:16 p.	-67.0	-66.2	15500	24200	(²⁰)	(²¹)
22	6:26 p.	-64.3	-64.3	15340	27340	26680	10250
23	7:55 p.	-64.6	-64.1	16940	24780	(²²)	(²³)
24	6:23 p.	-66.7	-66.7	14160	26780	27120	(²⁴)
25	6:24 p.	-64.8	-63.4	14290	29470	(²⁵)	28150
26	6:47 p.	-61.9	-61.5	15110	20600	21650	23980
27	1:57 a.	-65.0	-64.3	16590	26310	(²⁶)	(²⁷)
28	6:29 p.	-62.7	-62.7	15500	27170	27830	20700
29	2:06 a.	-62.8	-62.8	16530	19210	(²⁸)	16700
30	6:20 p.	-61.1	-61.1	13040	21900	25060	(²⁹)
31	2:05 a.	-63.8	-63.8	13590	24960	(³⁰)	21700
32	6:19 p.	-60.3	-59.4	13210	29020	28250	12550
33	2:15 a.	-61.4	-59.6	13990	22200	(³¹)	22350
34	6:26 p.	-62.6	-62.6	13250	31320	(³²)	22000
35	1:59 a.	-59.7	-59.0	12600	23560	(³³)	11400
36	6:21 p.	-59.3	-59.3	13010	28090	29440	23450
37	2:04 a.	-59.8	-59.8	13560	26340	(³⁴)	12300
38	6:21 p.	-59.1	-58.3	12790	27230	26800	7000
39	6:22 p.	-62.5	-62.5	15860	27000	27000	16400
40	6:20 p.	-61.6	-61.6	15530	20650	20400	13650
41	6:16 p.	-63.3	-61.0	15070	29260	(³⁵)	(³⁶)
42	7:30 p.	-66.3	-66.1	15370	27280	26310	25550
43	2:33 a.	-60.2			14100	(³⁷)	16800
44	6:23 p.	-65.0	-64.8	15010	27060	(³⁸)	26150
45	2:30 a.	(³⁹)					(⁴⁰)
46	6:35 p.	-2.6			5070	(⁴¹)	(⁴²)
47	2:00 a.						16750
48	6:30 p.	-63.0	-62.7	15810	27490	27900	25900
49	2:32 a.	-67.4	-66.3	17000	26490	(⁴³)	17650
50	6:27 p.	-64.5	-64.5	16200	27850	27700	22380

TABLE 2.—Tropopause and maximum elevation data for April 1939

Date	Time of release 90th meridian	Minimum temperature °C.	Temperature of tropopause °C.	Height of tropopause m. (M. S. L.)	Maximum height m. (M. S. L.)	Maximum height, from theodolite m. (M. S. L.)
1	5.36 p.	-63.0	-62.1	11290	22640	(¹)
2	5.27 p.	-65.2	-65.2	11770	21330	23640
3	5.27 p.	-63.2	-63.2	13000	22600	(²)
4	5.27 p.	(³)				
5	5.55 p.	-60.0	-60.0	11760	19320	19320
6	5.30 p.	-52.0	-52.0	8950	20310	(⁴)
7	5.53 p.	-55.6	-55.6	10280	21940	21940
8	5.50 p.	(⁵)				
9	5.44 p.	(⁶)				
10	6.00 p.	-58.1	-56.4	8620	18550	(⁷)
11	5.46 p.	-60.6	-57.3	11170	17190	17470
12	5.46 p.	-61.7	-59.2	11400	20580	20030
13	5.40 p.	-63.7	-63.7	12160	18320	(⁸)
14	5.42 p.	-64.2	-64.2	11710	20000	(⁹)
15	5.57 p.	-61.0	-61.0	12300	21430	(¹⁰)
16	5.42 p.	-56.8	-55.8	10440	20540	(¹¹)
17	5.41 a.	(¹²)				
18	5.46 p.	-56.4	-52.3	10490	18890	(¹²)
19	5.42 a.	-56.0	-54.5	10450	22660	(¹³)
20	5.43 p.	-58.4	-55.7	10780	17780	(¹⁴)
21	5.44 a.	-60.7	-55.3	10910	20440	20440
22	5.47 p.	-58.6	-57.7	10790	21350	(¹⁵)
23	5.40 a.	-56.8	-54.6	9460	21260	(¹⁶)
24	5.51 p.	(¹⁷)				
25	5.47 a.	-55.9	-55.7	11150	21550	27360
26	5.44 p.	-62.6	-62.6	12020	18730	18380
27	5.48 a.	(¹⁸)				
28	5.54 p.	-68.5	-68.5	12340	20060	19810
29	5.46 p.	-67.2	-67.2	12620	23600	(¹⁹)
30	5.43 p.	-61.7	-61.7	11940	20830	20830
31	5.50 p.	-59.2	-59.2	12830	27840	26080
32	5.45 p.	(¹⁹)				
33	5.51 p.	(²⁰)				
34	6.45 p.	-61.3	-61.1	12090	19480	(²⁰)
35	5.43 p.	-66.0	-66.0	12500	18400	19140
36	5.44 p.	(²¹)				

- ¹ Maximum height taken from theodolite data to compute pressures.
² Maximum height taken from ascensional rate of Fergusson and winds then computed.
³ Record undecipherable above this point.
⁴ Instrument not returned.
⁵ Balloon lost to view before bursting.
⁶ Record undecipherable.

- ¹ Maximum height taken from theodolite data to compute pressures.
² Maximum height taken from ascensional rate of Fergusson and winds then computed.
³ Record undecipherable above this point.
⁴ Instrument not returned.
⁵ Record plate missing from returned instrument.
⁶ Balloon lost to view before bursting.
⁷ Record undecipherable.

TABLE 3.—Wind directions and velocities for the surface and for each standard kilometer level, M. S. L., April 1939

Date	Time of release 90th meridian	Velocities in meters per second								
		Surface	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000
1	5:36 p.	WNW, 2.7	W, 5.7							
2	5:27 p.	WNW, 7.2	NNW, 9.5	NW, 11.7	NNW, 18.7	NW, 21.5	NW, 38.4	NW, 31.8	WNW, 33.6	NW, 39.6
5	5:55 p.	NW, 13.4	N, 15.3	NNW, 16.6	NNW, 24.1	WNW, 22.6	WNW, 37.7	W, 43.1	W, 42.1	W, 44.2
6	5:30 p.	W, 8.9	N, 18.4	NNW, 17.2	NNW, 17.2					
7	5:53 p.	NW, 9.8	NNW, 12.4	NW, 14.9	WNW, 17.2	NW, 27.0	NW, 22.0	NW, 31.6	NW, 32.2	NW, 31.5
8	5:50 p.	N, 3.1	NW, 2.8	WSW, 12.1						
9	5:44 p.	NNW, 7.2	NNW, 8.6	NW, 8.4	NNW, 11.0	W, 18.8	W, 31.9			
10	6:00 p.	NW, 6.7	NNE, 9.3	N, 12.2	N, 16.0	NNW, 14.9	NNW, 14.4	NW, 14.0		
11	5:46 p.	NW, 11.2	NNW, 12.7	NW, 15.9	NNW, 21.2	NW, 23.4	NW, 30.7	NNW, 38.3	WNW, 42.9	WNW, 47.4
12	5:46 p.	SE, 5.4	S, 6.3	W, 2.2	WNW, 9.1	WNW, 16.3	WNW, 21.5	WNW, 24.0	WNW, 27.1	WNW, 29.2
13	5:40 p.	SE, 8.5	SW, 18.4							
19	5:44 a.	W, 0.4	NW, 5.6	NNW, 12.1	N, 20.8	N, 17.9	NNW, 19.6	NNW, 23.0	NNW, 30.1	NNW, 30.7
19	5:47 p.	SSW, 5.4	SW, 6.8	WNW, 12.5	NNW, 13.8	NW, 14.3	NW, 17.0	NW, 17.7	NW, 18.1	WNW, 20.0
19	5:40 a.	W, 3.1	N, 13.0		NNW, 11.0	NNW, 17.5				
20	5:44 p.	NNW, 4.9	NNW, 13.1	NNW, 15.2	NNW, 17.4	NNW, 21.5	NNW, 23.8	N, 31.8	N, 37.0	N, 38.8
21	5:47 a.	W, 3.1	W, 6.6	NNW, 8.2	NW, 16.7	NW, 19.2	NNW, 24.7	NNW, 29.6	NNW, 33.2	NNW, 32.4
21	5:44 p.	SSE, 4.9	SSW, 25.8	WSW, 5.5	WNW, 6.8	NW, 12.7	NW, 14.2	NW, 14.4	WNW, 17.1	WNW, 16.7
22	5:45 p.	S, 8.0	SSW, 19.9	SW, 14.0	SW, 19.6	W, 17.8	W, 13.4	WNW, 11.4	WNW, 14.4	WNW, 17.8
23	5:54 p.	S, 9.8	SSW, 19.4	WSW, 15.1	WSW, 15.8	WSW, 17.8	WSW, 17.6	W, 12.4	WSW, 8.9	SW, 11.9
24	5:43 p.	S, 13.0	S, 16.4	SSW, 17.4	SW, 12.8	SSW, 13.2	SSW, 20.2	SSW, 23.4	SSW, 22.4	SSW, 23.6
25	5:50 p.	NNW, 5.4	NW, 6.2	NW, 3.5	WNW, 8.4	SW, 18.3	WSW, 15.1	WSW, 18.1	WSW, 20.0	WSW, 19.8
27	5:51 p.	NNW, 9.8	N, 14.3	NNW, 13.8	N, 16.2	N, 14.3	NNE, 22.0	NNE, 25.5	NNE, 34.7	NNE, 34.1
28	5:45 p.	NE, 6.7	N, 3.3	NE, 10.0	NNE, 8.2	NE, 8.0	NNE, 10.7	N, 9.7	N, 13.6	NNW, 12.7
29	5:43 p.	SSE, 4.0	SSW, 4.8	SW, 3.7	SW, 2.2	NNW, 1.2	N, 2.5	N, 5.6	N, 5.6	N, 8.6
30	5:44 p.	SSE, 4.0	S, 2.5	SW, 3.0	N, 6.2	N, 8.1	NNW, 9.3	N, 6.9	NNW, 10.6	NNW, 10.1

Date	Time of release 90th meridian	Velocities in meters per second								
		9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000
1	5:36 p.									
2	5:27 p.	NW, 43.2	WNW, 44.2	WNW, 48.7	WNW, 44.1	WNW, 40.8	WNW, 34.7	WNW, 32.5	NW, 29.3	WNW, 24.2
5	5:55 p.	WSW, 46.5	SW, 49.1	SW, 47.2	W, 38.1	WSW, 30.0	W, 40.0	W, 20.5	W, 20.5	WNW, 6.1
6	5:30 p.									
7	5:53 p.	NW, 34.6	NW, 35.9	NNW, 28.2	NW, 23.6	NW, 21.0	WNW, 20.0	WNW, 21.0	WNW, 29.9	WNW, 17.1
8	5:50 p.									
9	5:44 p.									
10	6:00 p.									
11	5:46 p.	WNW, 55.9	WNW, 51.8	WNW, 46.5	WNW, 29.6	W, 26.6	W, 30.5	W, 24.2	WNW, 23.5	W, 19.4
12	5:46 p.	WNW, 30.4	WNW, 34.2	W, 45.7	W, 42.5	WNW, 39.3	W, 29.5	W, 23.2	WNW, 25.2	WNW, 19.6
13	5:40 p.									
19	5:44 a.	N, 27.1	N, 26.4	NNW, 26.7	NNW, 25.4	NW, 20.6	NW, 24.8	NW, 22.4	NW, 14.3	WNW, 18.5
19	5:47 p.	WNW, 23.0	WNW, 24.4	WNW, 30.0	WNW, 24.2	WNW, 24.5	WNW, 25.4	WNW, 24.3	WNW, 16.8	WNW, 13.3
20	5:40 a.									
21	5:47 a.	N, 41.1	N, 39.1	NNW, 33.2	NNW, 27.2	NW, 20.4	NW, 16.0	NW, 15.9	NW, 10.6	WNW, 10.5
21	5:44 p.	NNW, 34.4	NNW, 40.6	NNW, 42.4	NNW, 31.8	NW, 17.4	NW, 21.0	NW, 17.3	WNW, 11.6	W, 11.6
22	5:48 a.	WNW, 20.3	WNW, 19.3	WNW, 22.2	WNW, 23.0	WNW, 24.5	WNW, 19.3	NW, 17.9	WNW, 11.6	WNW, 14.0
22	5:54 p.	NW, 20.8	WNW, 25.6	NW, 26.4	NW, 27.4	NW, 23.1	WNW, 20.1	WNW, 16.3	WNW, 19.5	WNW, 17.5
23	5:46 p.	WSW, 13.7	WNW, 6.3							
24	5:43 p.	SSW, 29.4	SSW, 32.2	SSW, 34.7	SSW, 27.7	SSW, 19.9	SW, 18.4	WSW, 11.1	W, 2.6	WNW, 1.6
25	5:50 p.	WSW, 23.2	WSW, 23.2	WSW, 19.5	WSW, 24.8	WSW, 19.8	WSW, 11.6	WSW, 11.1	SSW, 11.2	SW, 12.0
27	5:51 p.	NNE, 34.8	NNE, 34.2	NNE, 34.7	NNE, 34.8	N, 19.4	NNW, 12.2	NW, 13.5	WNW, 6.5	NNW, 3.9
28	5:45 p.	NNW, 15.6	NNW, 16.0	NNW, 15.4	NNW, 17.6	NNW, 11.8	NNE, 11.0	NNW, 12.5	N, 10.4	NNW, 9.4
29	5:43 p.	N, 10.8	NNE, 11.0	NNE, 12.6	NNE, 16.8	NE, 19.6	NNW, 8.8	NNW, 15.4	N, 8.3	NNW, 13.1
30	5:44 p.	NNW, 10.7	N, 13.5	NNW, 11.4	NNW, 12.1	NNW, 14.3	N, 16.1	N, 16.4	NNW, 17.0	

Date	Time of release 90th meridian	Velocities in meters per second									
		18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	26,000	27,000
1	5:36 p.										
2	5:27 p.	WNW, 16.9	NW, 14.8	WNW, 10.2	W, 11.4	WNW, 12.5	W, 6.4				
5	5:55 p.	WNW, 5.1	W, 14.5								
6	5:30 p.										
7	5:53 p.	WNW, 20.6	WNW, 16.0	WSW, 12.0	W, 11.9	W, 12.8					
8	5:50 p.										
9	5:44 p.										
10	6:00 p.										
11	5:46 p.										
12	5:46 p.	W, 16.2	WNW, 7.8	W, 8.9							
13	5:40 p.										
19	5:44 a.	WNW, 14.4	WNW, 10.8	W, 7.2							
19	5:47 p.	WNW, 18.4									
20	5:40 a.										
21	5:47 a.	W, 5.2	W, 10.5	WSW, 11.6	W, 7.8	SSW, 8.3	WSW, 15.4	WSW, 14.5	SW, 11.0	SW, 19.1	WSW, 20.8
21	5:44 p.	W, 8.8									
21	5:48 a.	WNW, 9.7	WSW, 16.6	W, 14.9	NW, 10.8						
22	5:54 p.	NW, 14.8	NW, 13.9								
23	5:46 p.										
24	5:43 p.	S, 1.1	WNW, 2.2	NW, 7.2	N, 5.6						
25	5:50 p.	SW, 10.7	SW, 11.0	SW, 7.6	NE, 2.8	SSW, 1.7	W, 5.9	WNW, 10.2	NW, 9.0	NW, 10.8	
27	5:51 p.	WSW, 6.4									
28	5:45 p.										
29	5:43 p.	NNW, 8.4	NNW, 6.2								
30	5:44 p.	NNE, 11.4	N, 9.0	N, 9.3	NNE, 6.0	N, 3.0	NNW, 6.8	NW, 3.0	W, 8.4		